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Mathematical Problem-Solving Ability of Grade X Students on Trigonometry Through Problem Based Learning with Plotagon-Based Animation Media

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Abstract: *This research aims to describe the mathematical problem-solving abilities of tenth-grade students on trigonometry material thru the Problem Based Learning (PBL) model assisted by Plotagon-based animation media. The type of research used is descriptive research with a qualitative and quantitative approach. The subjects of this study are 23 tenth-grade students from SMA Negeri 1 Indralaya Utara in the even semester of the 2025/2026 academic year. Data collection was conducted thru a written test consisting of one contextual problem with six essay questions referring to Polya's indicators (1973), a Problem-Based Learning (PBL) Student Worksheet (LKPD) completed in groups, and semi-structured interviews with three selected subjects. Problem-solving ability is measured based on four Polya indicators: understanding the problem, devising a plan, carrying out the plan, and looking back. The research results show that students' mathematical problem-solving abilities overall fall into the moderate category with an average score of 72.46. The category distribution indicates 5 students in the high category and 18 students in the moderate category, with no students in the low category. The average achievement per indicator is: understanding the problem 72.66 (medium), making a plan 76.16 (medium), executing the plan 68.12 (medium), and checking back 69.57 (medium). The combination of PBL and Plotagon animation media has proven effective in building students' contextual understanding, but individual procedural skills and explicit verification habits still need to be strengthened.*
Keywords: *Mathematical problem-solving, Problem based learning, Plotagon animation, trigonometry*

1. INTRODUCTION

The ability to solve mathematical problems is one of the essential competencies that students must possess in facing the challenges of the 21st century. This competence not only plays a role in solving math problems in class but is also very important in daily life, which demands the ability to think logically, systematically, and creatively. National Council of Teachers of Mathematics (NCTM) [1] states that problem-solving is the main focus of mathematics education because it can train students to understand situations, design strategies, and evaluate solutions independently. Thru problem-solving activities, students learn to work collaboratively, think critically, and have perseverance in overcoming challenges [2].

However, the mathematical problem-solving skills of Indonesian students are still relatively low. The PISA 2022 report released by the OECD [3] revealed that Indonesian students' problem-solving scores are below the global average, partly due to the dominance of rote memorization methods and an education system that still overly focuses on standardized tests. Saija's longitudinal study [4] over four years (2021–2024) consistently found that each year, there are always seventh and eighth-grade students with low mathematical problem-solving abilities scattered across various regions in Indonesia. Additional findings from Norlita et al. [5] indicate that the teacher-centered learning model causes students to tend to be passive, easily bored, and completely dependent on the teacher's explanations.

One of the solutions that can be applied is the Problem Based Learning (PBL) model. PBL is a learning approach that begins with the presentation of real or contextual problems to students, who then actively seek solutions thru investigation, group discussions, and various problem-solving strategies [6]. In this model, the role of the teacher shifts from being a source of information to a facilitator, thereby optimizing student engagement and independence [7]. Several studies have proven the effectiveness of PBL: Nursanti et al. [8] reported that PBL assisted by animated videos in eighth-grade mathematics successfully increased students' average scores from 73.64 to 85.22 and the percentage of completeness from 50% to 87.5%; Nuraenun Ilahi et al. [9] found that PBL with animations resulted in an average learning activity of 78.88 and an average learning outcome of 83.88, significantly higher than the control class. These findings are also in line with research that shows PBL positively contributes to students' critical thinking and problem-solving skills [23].

Beside the learning model, the use of appropriate media also plays an important role. Plotagon Studio is a 3D animation film-making application that allows users to create animated characters, add dialog, and present educational content in the form of engaging visual stories [10]. When integrated with PBL, Plotagon can present contextual problems thru animated narratives, making it easier for students to visualize and understand the problem situation before solving it. Mubarok and Setiawan [11] developed Plotagon-based animation media on probability material using the PBL approach and found a significant improvement in conceptual understanding. Similar findings were reported by Shinta et al. [12] using Powtoon animation in PBL, Ningrum et al. [13] who systematically reviewed video-assisted PBL to improve mathematical problem-solving skills, and Kusumawati et al. [22] who demonstrated that animation-based learning videos support students' understanding of mathematicalconcepts.

Trigonometry is one of the subjects that consistently poses difficulties for 10th-grade students because it requires conceptual understanding, geometric representation, and systematic procedure application—all of which are skills closely related to problem-solving [14]. Although research on PBL and animation media continues to develop, there is still a gap in studies that specifically describe students' mathematical problem-solving abilities in trigonometry using Plotagon animation media with in-depth qualitative analysis per Polya's indicators. This research aims to fill that gap. The objective of the research is to describe the mathematical problem-solving abilities of tenth-grade students on trigonometry material thru the PBL model assisted by Plotagon-based animation media based on four Polya indicators [15].

2. METHOD

This research uses a descriptive research design with qualitative and quantitative approaches. The research was conducted at SMA Negeri 1 Indralaya Utara, South Sumatra, Indonesia, in the even semester of the 2025/2026 academic year over two meetings (February 4 and 12, 2026). The research subjects were 23 tenth-grade students who were purposively selected based on the recommendation of the mathematics teacher. All students participated in PBL learning assisted by Plotagon-based animation media on trigonometry material. Data were collected thru three instruments. First, a written test of mathematical problem-solving ability (KPMM) in the form of a contextual problem scenario where a technician measures the height of a billboard using the angle of elevation, with six descriptive questions distributed across four Polya indicators [15], [16] presented in Table 1 below. The use of PBL-based LKPD in this study also refers to the development of Problem Based Learning-based learning devices that emphasize higher order thinking skills activities [24].

No	Indicator	Deskripsi
1	understanding the problem	Students are able to identify the components of the problem, including what is known and what is being asked.
2	Creating a problem-solving plan	Based on the information provided, students are able to create a methodical plan for solving problems.
3	Implementing the problem-solving plan	Students can apply the strategies or plans for problem-solving that have been decided upon in order to solve problems.
4	Rechecking the problem-solving results	Students are able to check or verify the accuracy of the results obtained and draw conclusions.

Data collection involves data triangulation: observation, written tests, and semi-structured interviews. Observations were conducted during the learning process. The assessment system for problem-solving ability tests is explained in detail in Table 2, covering the indicator rubric:

Table 2, covering the indicator rubric:

Skor	Scoring Indicator
	Indicator 1: Understanding the Problem
3	Able to write down known and asked things completely and correctly
2	Able to write down known and asked things, but incomplete or partially incorrect.
1	Able to write down known and asked things, but not accurately
0	Unable to write down what is known and what is asked.
	Indicator 2: Creating a Problem-Solving Plan
3	Able to create a complete problem-solving plan that leads to the correct answer.
2	Able to create problem-solving plans that lead to correct but incomplete answers or incorrect answers.
1	Able to create a problem-solving plan but leads to the wrong answer.
0	Unable to create a problem-solving plan
	Indicator 3: Implementing the Problem-Solving Plan
3	Able to write correct solution procedures and obtain correct results.
2	Able to write a solution procedure that leads to the correct answer but is incorrect in the solution.
1	Able to write solutions but the procedure is unclear.
0	Unable to write the solution procedure
	Indicator 4: Reviewing the Results of Problem Solving
3	Able to write conclusions and thoroughly and accurately check the answers.
2	Able to write conclusions and check the answers again but not complete or not accurate enough.
1	Able to write conclusions and check the answers again but not accurate.
0	Unable to write a conclusion and review the answers.

Next, the researcher determines the test score using the following formula.

$$Test\ score = \frac{total\ score\ obtained}{maximum\ score}\ x\ 100$$

Explanation: Maximum score = maximum score per question × number of questions = 18 × 1 = 18

The researcher will obtain the emergence of indicators of students' mathematical problem-solving abilities after obtaining test scores. After the test scores are obtained, the researcher categorizes each student's score into three categories. The score ranges for each category of students' mathematical problem-solving abilities in trigonometry material can be seen in the following table.

Table 2 The score ranges

Value	Category
80 – 100	High
50 – 79	Currently
0 – 49	Low

Modification (Rofiqoh et al., 2020)

The researcher will describe the subjects' abilities in solving mathematical problems on trigonometry material thru Problem Based Learning (PBL) assisted by Plotagon-based animation media, based on the emergence of each designed indicator of mathematical problem-solving abilities. A descriptive approach like this aligns with an exploratory study of mathematical problem-solving abilities based on students' mathematical skills.

3. RESULTS AND DISCUSSION

3.1 Overall Mathematical Problem-Solving Ability

The distribution of students' mathematical problem-solving ability categories based on written test results is presented in Table 3.

Table 3. Distribution of Student Mathematical Problem-Solving Ability Categories

Kategori	Value Range	many students
High	80 – 100	5
Currently	50 – 79	18
Low	0 – 49	0
Total	-	23

Table 3 shows that there are no students in the low category. Most students are in the medium category, while 5 students (21.74%) reach the high category. The overall average score of 72.46 places the class's problem-solving ability in the moderate category. These findings indicate that the combination of the PBL model and Plotagon animation media has a positive impact on students' mathematical problem-solving abilities, in line with Susino et al. [18] who concluded that PBL significantly affects the mathematical problem-solving abilities of tenth-grade high school students, and Sumartini [19] who found that problem-based learning results in significantly better problem-solving abilities compared to conventional learning. The achievement pattern still dominated by the moderate category is also in line with exploratory findings on students with diverse mathematical abilities [25]. Table 4 presents the average achievement per Polya indicator.

Table 4. Average Achievement per Polya Indicator

No	Indicator Polya	Rata-rata (%)	Kategori
1	Memahami Masalah	72,66	Currently
2	Membuat Rencana Pemecahan Masalah	76,09	Currently

3	Melaksanakan Rencana Pemecahan Masalah	68,12	Currently
4	Memeriksa Kembali Hasil Pemecahan Masalah	69,57	Currently

All four Polya indicators are in the moderate category with an average range between 68.12 and 76.09. The indicator with the highest achievement is making a problem-solving plan (76.09), while the lowest achievement is in the indicator of executing the problem-solving plan (68.12). In-depth analysis of each indicator is detailed in the following subsection.

1) Understanding the Problem

Students' ability to understand the problems in questions number 1 and 2 is overall in the moderate category with an average of 72.66. In PBL-based learning, this indicator is facilitated thru the problem orientation syntax, namely when students watch a Plotagon animation that depicts a scenario of a technician who intends to measure the height of a billboard using the angle of elevation. The animation media presents the problem context visually, making it easier for students to imagine real-life situations. However, the LKPD data shows that most groups made similar mistakes, namely classifying the height of the building as known information, whereas that variable is the one being asked. These findings indicate that the visual stimulus from the Plotagon media, although effective in building context, has not yet fully encouraged students to identify data in a structured and systematic manner.

In the individual written test, the ability to understand the problem remains in the moderate category. Students tend to write down known information, such as distance and elevation angle, without including specific numerical values, and often mix factual data with the narrative of the problem. Analysis of the interview data revealed variations in understanding patterns among the three selected subjects. Subject S-01 (NNZ) was able to identify the components of the problem contextually well, including explaining the position of the side as the horizontal distance from the base of the building to the technician's position, which indicates that the visual understanding built thru Plotagon animation has been well internalized. Subject S-02 (ZAK) wrote the information in a lengthy narrative format because they attempted to explain the situation thoroughly; their conceptual understanding was actually adequate, but the student had not yet mastered the concise and structured conventions of mathematical writing. As for Subject S-03 (IZ), they tend to immediately focus on the solution when asked to state the known information, and only manage to identify the data correctly after receiving guidance. This condition indicates that the process of data identification has not yet formed as an automatic thinking habit. These findings are in line with [20], which states that the biggest mistakes high school students make in trigonometry problems occur at the stage of understanding the problem, and [26], which found that students generally have been able to write down information from the problem, but some have not been able to write it down completely and ideally. Thus, the problem orientation syntax in PBL and the visual stimulus of Plotagon have formed contextual understanding, but it needs to be followed by structured practice in writing mathematical problem identification.

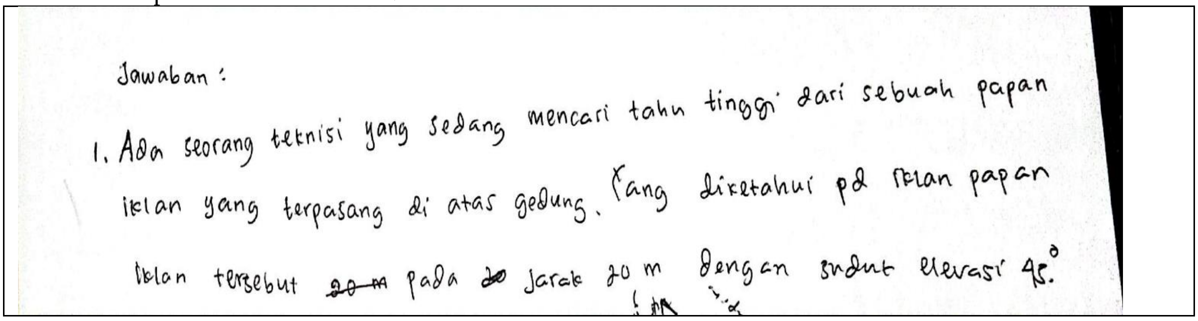

Figure 1. Example of student answers on the indicator of understanding the problem

In line with the findings of [20] that the biggest mistakes made by high school students on trigonometry problems occur at the stage of understanding the problem, and [26] which states that students in general are able to write down information from the problem, but some are not yet able to write it down completely and ideally. These findings indicate that the problem-oriented syntax in PBL and the visual stimulus of Plotagon have successfully formed students' contextual understanding, but this needs to be followed by structured practice in mathematically writing problem identification.

2) Creating a Problem-Solving Plan

Students' ability to create a problem-solving plan in questions number 3 and 4 falls into the moderate category overall, with an average of 76.09. In the PBL model, this indicator develops within the syntax of learning organization and group investigation, specifically when students discuss to determine problem-solving strategies based on information obtained from the Plotagon animation. Plotagon media displays illustrations of right-angled triangles with elevation angles that help students relate contextual situations to geometric representations, thereby forming a conceptual foundation in the selection of trigonometric functions. The LKPD data shows that this indicator received an average score of 2.75 in the high category, indicating that the visual stimulus from Plotagon is very effective in building planning skills in the context of group work. The identified weakness does not lie in the accuracy of formula selection, but rather in the students' ability to articulate the reasons for their strategy selection both mathematically and in writing.

Interview data analysis revealed that the weakness was expressive, not conceptual. Subject S-01 (NNZ) expressed strong conceptual confidence in the selection of the tangent function, although it was articulated intuitively without an explicit procedural explanation. Subject S-02 (ZAK) wrote an incorrect reason on the answer sheet, but during the interview, he was able to explain the selection of the tangent function accurately based on known elements, namely the side and elevation angle. The gap between oral and written abilities aligns with the findings of [21] that students with moderate abilities can plan a solution using one strategy, although they are not yet able to articulate their reasoning fully in writing. The collaboration of PBL and Plotagon visualization has proven successful in building an understanding of trigonometric concepts as a basis for planning, but students still need to be trained to articulate mathematical reasoning in writing ([27]).

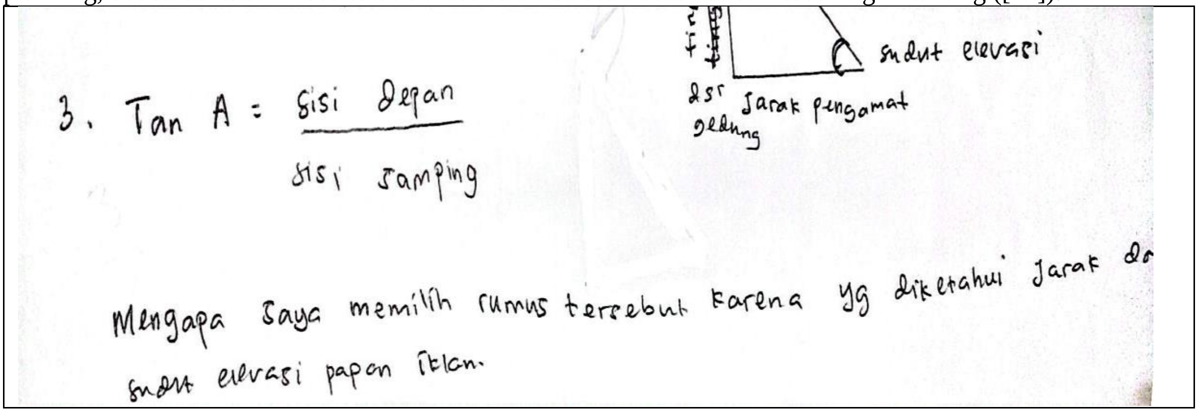

Figure 2. Example of student responses on the indicator of creating a problem-solving plan

3) Implementing the Problem-Solving Plan

Students' ability to implement the problem-solving plan as a whole falls into the moderate category with an average of 68.12. This indicator is the lowest achievement among the four Polya indicators. In the PBL model, this indicator develops in the syntax of individual or group investigations, when students actively work on problems based on the plan that has been prepared. The role of Plotagon at this stage is indirect; the previously displayed animation has built an understanding of the context and concept, thus serving as a foundation for students in carrying out the problem-solving procedure. The LKPD data shows the most outstanding results among the four indicators, with an average score of 3.00 in the high category for all groups. This indicates that in the context of group work assisted by LKPD, discussion and collaboration are able to encourage all students to achieve procedural completeness. However, when tested individually in a written exam, the results obtained were significantly different. Interview analysis revealed variations in understanding among the selected subjects. Subject S-01 (NNZ) demonstrated a deep conceptual understanding in explaining the solution procedure using the tangent ratio, rather than merely memorizing the formula.

In contrast, Subject S-03 (IZ) did not work on question number 5 not due to an inability to calculate, but because they combined the answer to question number 5 with question number 4. The misunderstanding of the function of each test item indicates the need for strengthening the understanding of test instructions, while also suggesting that the process of completing the LKPD with Plotagon assistance has not yet fully permeated the students' individual understanding. The misunderstanding of the function of each test item indicates the need for strengthening the understanding of test instructions and is suspected to occur because the process of completing the LKPD with Plotagon assistance has not yet optimally permeated the students' understanding. The difference between the LKPD and test achievements confirms the findings of [28] that PBL learning needs to be supplemented with more intensive individual practice so that students' procedural independence can be evenly developed.

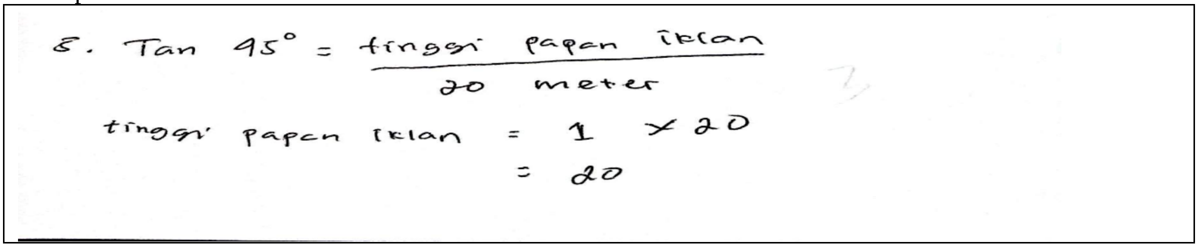

Figure 3. Example of student answers on the indicator of implementing problem-solving plans

4) Reviewing Problem-Solving Results

Students' ability to review problem-solving results falls into the moderate category with an average of 69.57. In the PBL model, this stage should develop in the evaluation and reflection syntax, where the teacher encourages students to review the group's answers before presenting them. However, the LKPD data actually shows that this indicator is the weakest, with one group scoring 0 because they did not carry out the verification process at all. This condition indicates that the evaluation syntax in the implementation of PBL has not been running optimally. In the individual written test, the three selected subjects showed attempts at verification using the Pythagorean Theorem, but with varying levels of completeness. Subject S-01 (NNZ) performed two verification methods, namely using the Pythagorean Theorem and the value of Sin 45°, although the verification with sine was not completed thoroughly. Subject S-02 (GLA) performed two verification methods with a more systematic rationalization process.

Meanwhile, Subject S-03 (IZ) performed verification using the Pythagorean Theorem, but there were errors in the calculation process and the conclusion drawn. The phenomenon of weak rechecking ability is consistent with previous research findings. [20] reported that the percentage of errors made by high school students during the review stage of trigonometry problems reached 17.16%. [21] also found that students with moderate ability tend not to recheck their answers after obtaining them. The weakness in this indicator may be caused by two main factors: the assumption by students that the verification process is unnecessary after an answer is found, and the limited allocation of time for test completion. This finding serves as an important note for future learning, particularly for teachers to explicitly and systematically train students to consistently perform verification and draw specific and measurable conclusions from each calculation result.

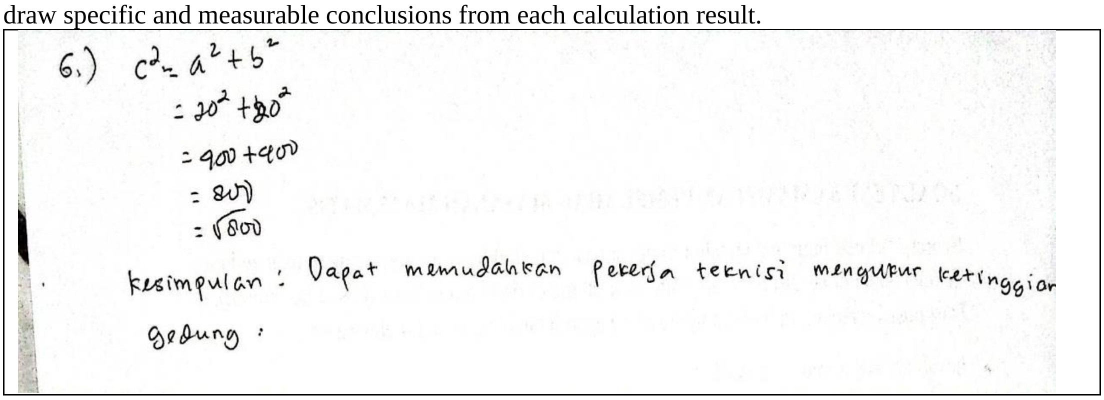

Figure 4. Example of a student’s response to the indicator reviewing the results of problem-solving

4. CONCLUSION

Based on the research results, the mathematical problem-solving abilities of tenth-grade students on trigonometry material thru the Problem Based Learning (PBL) model assisted by Plotagon-based animation media are overall in the moderate category with an average score of 72.46. No students were found in the low category, with a distribution of 5 students (21.74%) in the high category and 18 students (78.26%) in the moderate category. Analysis per Polya's indicators shows that all four indicators are in the moderate category, with the following details: (1) understanding the problem obtained an average of 72.66; (2) making a problem-solving plan obtained the highest average of 76.09; (3) executing the problem-solving plan obtained the lowest average of 68.12; and (4) checking the problem-solving results obtained an average of 69.57. The combination of the PBL model and Plotagon animation media has proven effective in building contextual understanding and students' planning abilities, particularly in the problem orientation and group investigation stages. However, there is a gap between group work achievements (LKPD) and individual tests, indicating that students' procedural independence has not been evenly developed. The habit of reviewing and drawing explicit conclusions also needs to be strengthened. Therefore, it is recommended that teachers complement the implementation of PBL with more intensive individual exercises, structured answer verification habits, and strengthened scaffolding in writing problem identification and mathematical reasoning.

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